

# Impact of Upgrading Land Surface Model and Land Surface Initial Conditions in Seasonal 3-Month Forecasts of the Experimental NCEP Climate Forecast System

With respect to 10-year climate of given CFS model from 10-member ensemble of CFS hindcasts from April-May initial conditions

## CFS Test A: Control

- old OSU LSM
- GR2 initial land states

## CFS Test B:

- new Noah LSM
- GR2 initial land states

## CFS Test C:

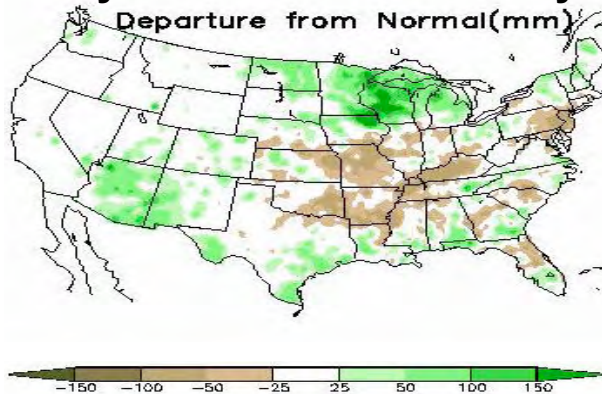
- new Noah LSM
- GLDAS initial land states

## CFS Test D:

- New Noah LSM
- GLDAS climo initial land states

FIGURE 1

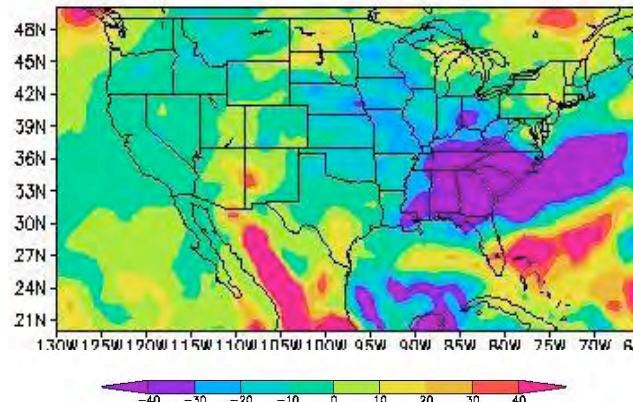
## July 99 Observed Anomaly



## CFS Predicted July 1999 Precipitation Anomaly (mm)

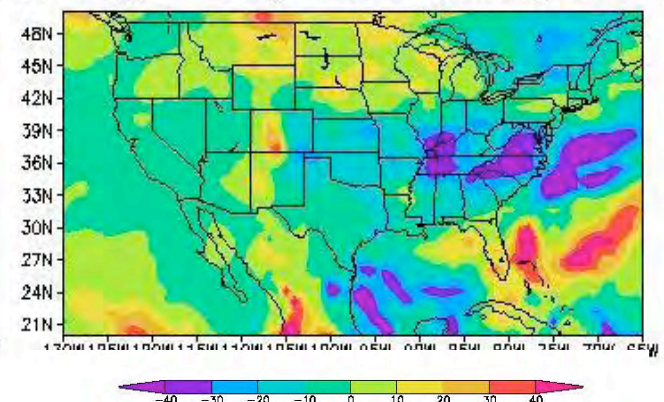
### CFS Test A: Control T126 CFS / OSU / GR2

99 July - July Climo (OSU/GR2)



### CFS Test C: T126 CFS / Noah / GLDAS

99 July - July Climo (Noah/GLDAS)

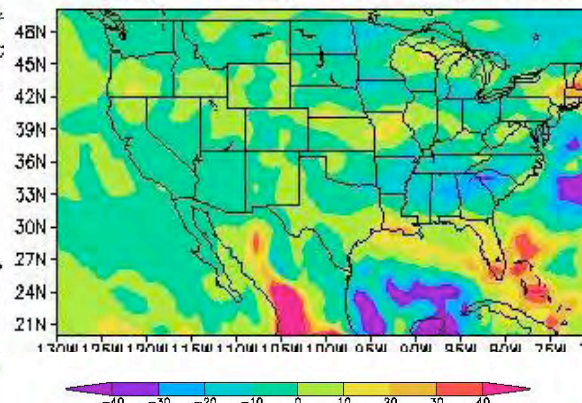


Black Circles: Worse than Case C

White Circles: Best or decent

### CFS Test B: T126 CFS / Noah / GR2

99 July - July Climo (Noah/GR2)



### CFS Test D: T126 CFS / Noah /GLDAS-climo

99 July - July Climo (Noah/GLDAS-climo)

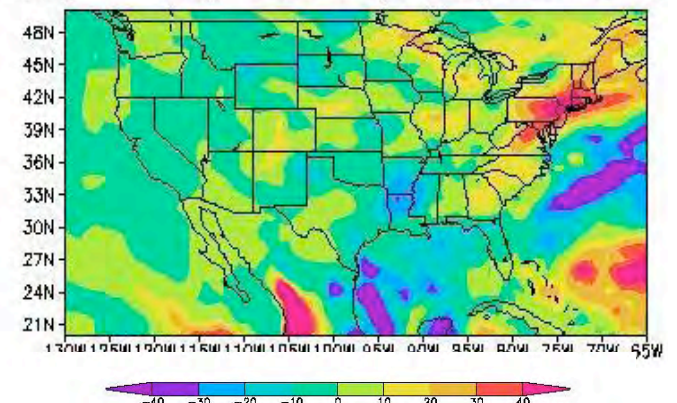


FIGURE 2

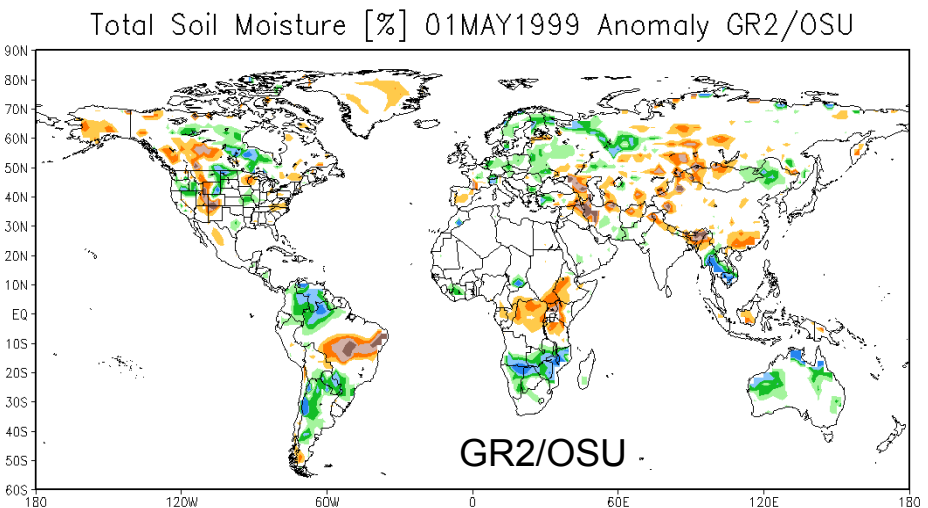
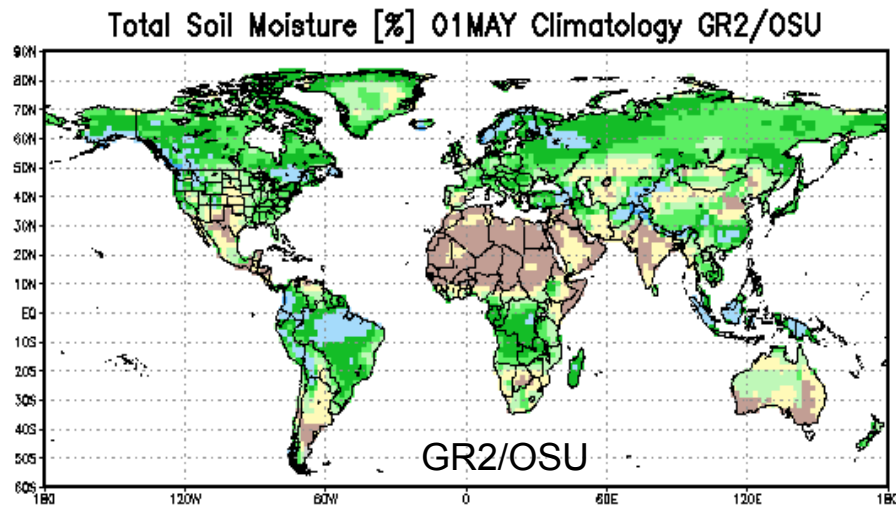
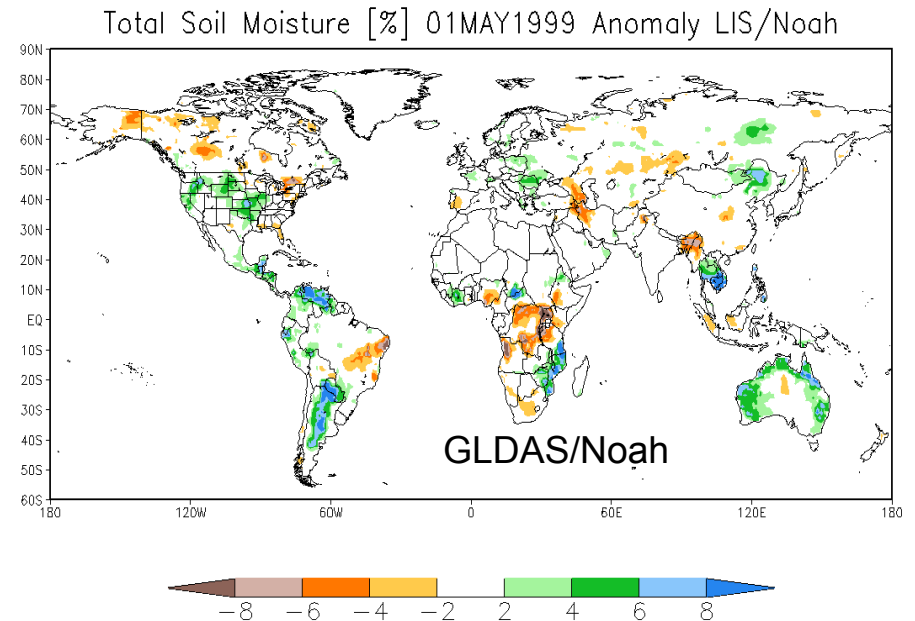
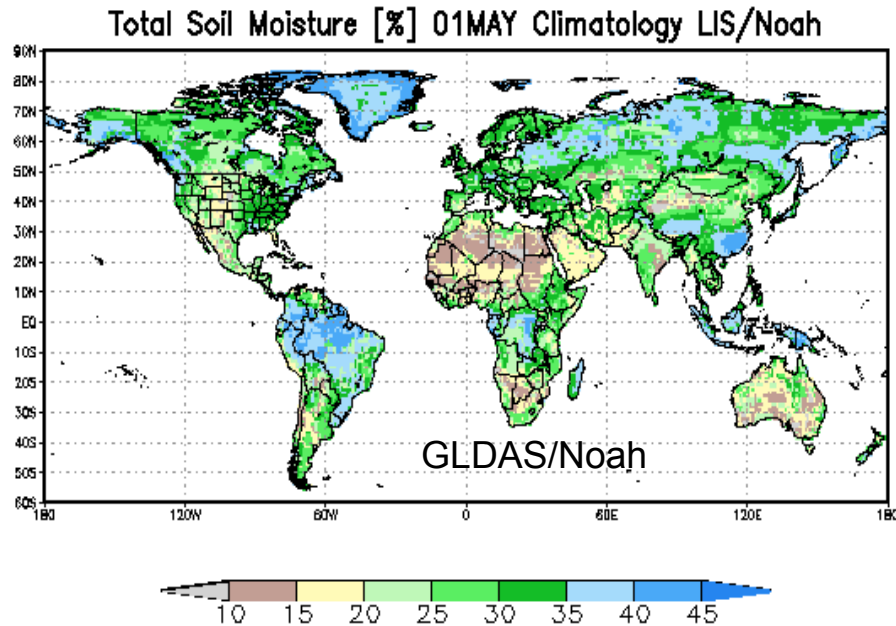
GLDAS/Noah ([top](#)) versus GR2/OSU ([bottom](#))

**2-meter soil moisture (% volumetric)**

(Climatology is from 25-year period of ~1981-2005)

May 1<sup>st</sup> **Climatology**

01 May 1999 **Anomaly**





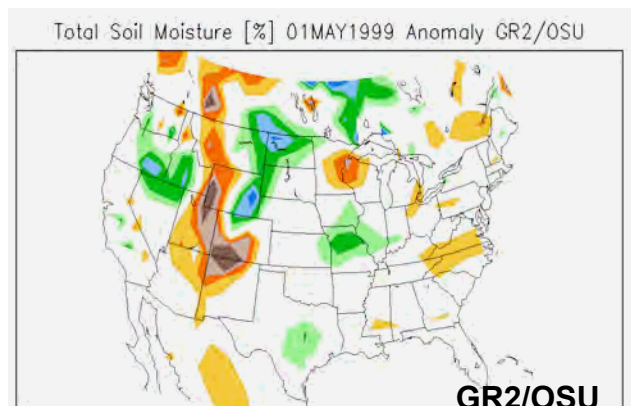
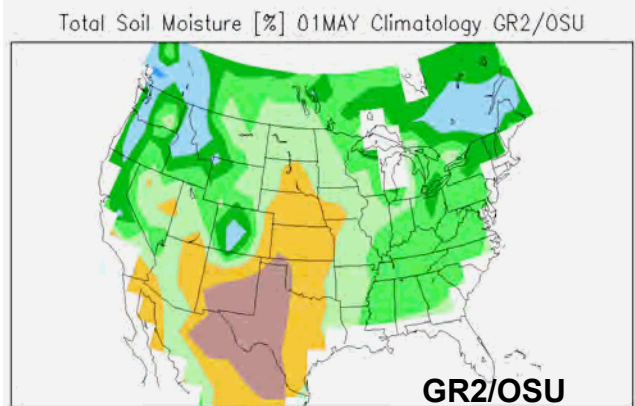
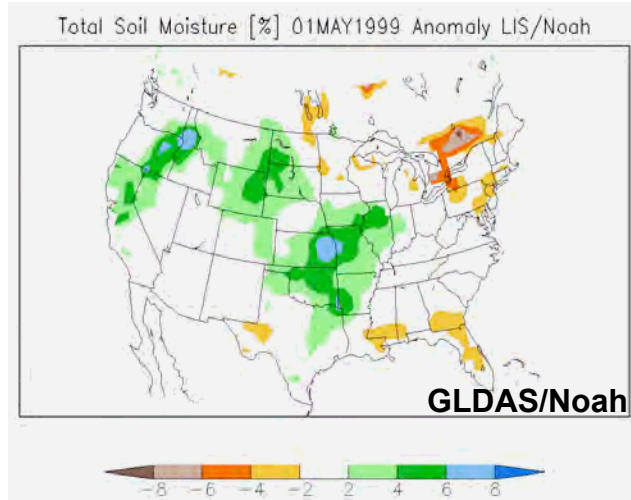
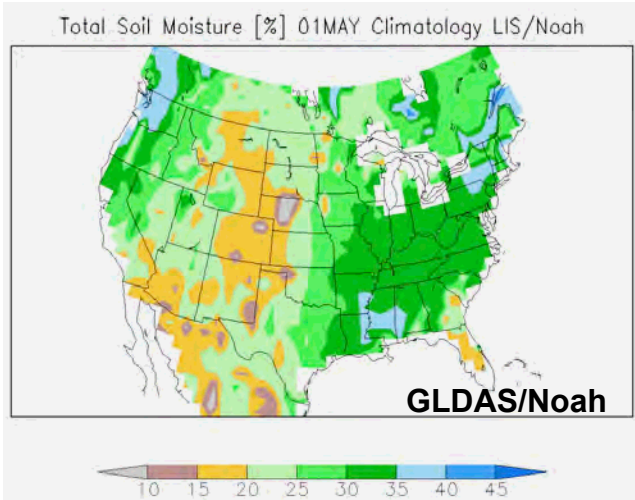
# GLDAS/Noah (top) versus GR2/OSU (bottom)

## 2-meter soil moisture (% volumetric)

(Climatology is from 25-year period of ~1981-2005)

May 1<sup>st</sup> **Climatology**

01 May 1999 **Anomaly**



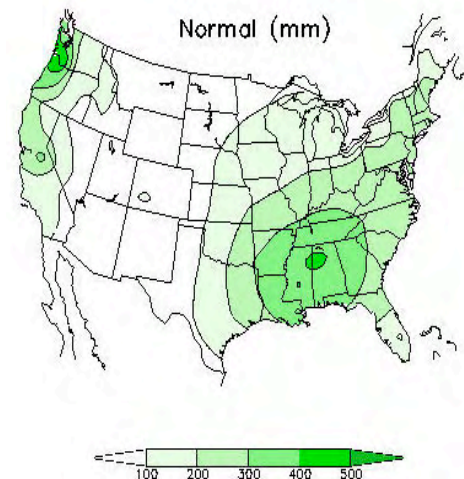
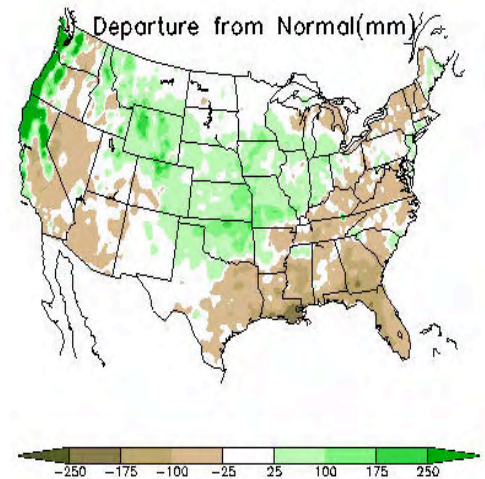
**Left column:** GLDAS/Noah soil moisture climo is generally higher than GR2/OSU

**Middle column:** GLDAS/Noah soil moisture anomaly pattern agrees better than that of GR2/OSU with observed precipitation anomaly (right column: top)

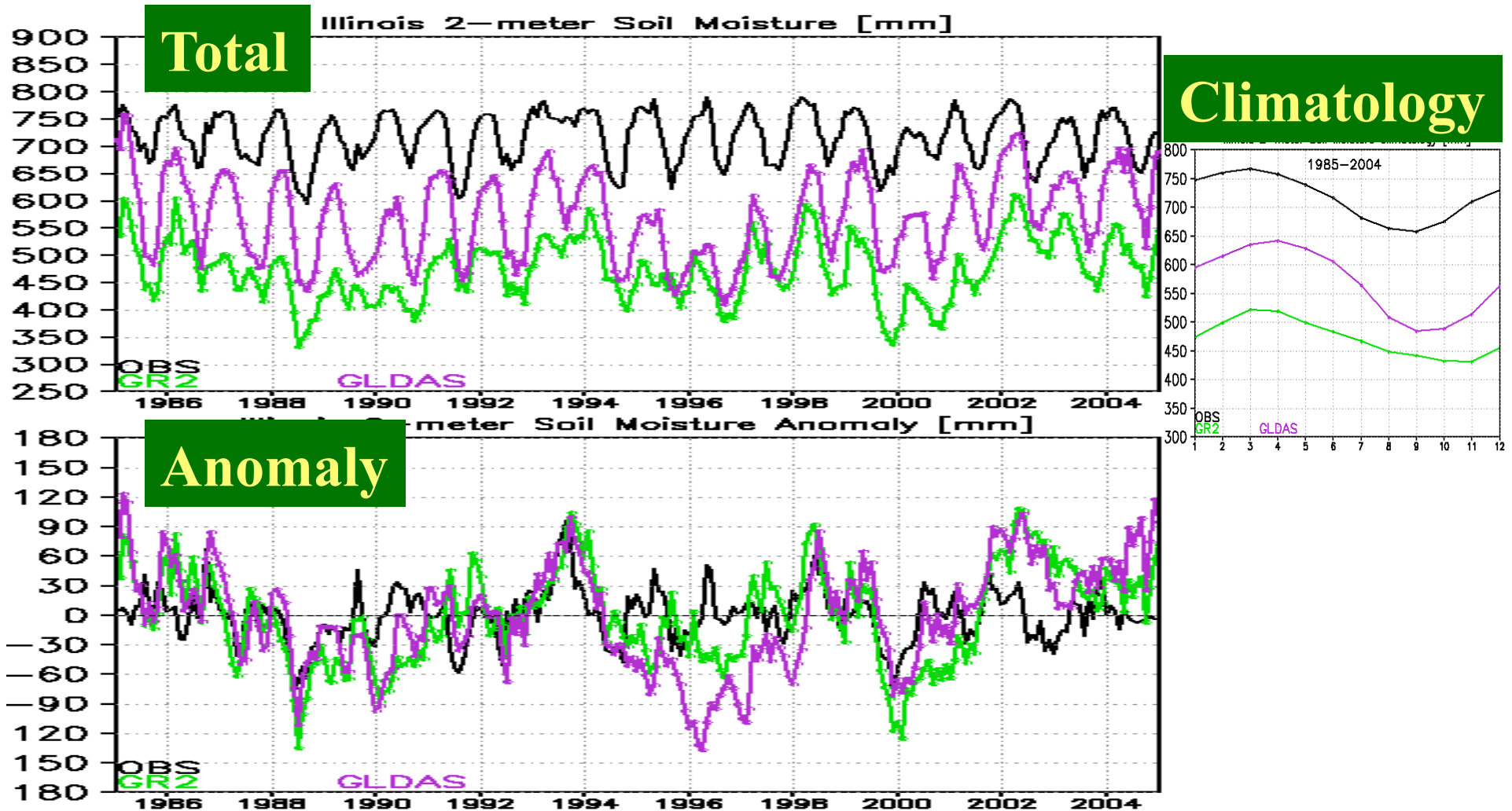
## FIGURE 3

**Top: observed 90-day  
Precipitation Anomaly  
(mm) valid 30 April 99**

**Bottom: Climatology**



**FIGURE 4** Monthly Time Series (1985-2004) of Area-mean Illinois 2-meter Soil Moisture [mm]:  
Observations (black), GLDAS/Noah (purple), GR2/OSU (green)



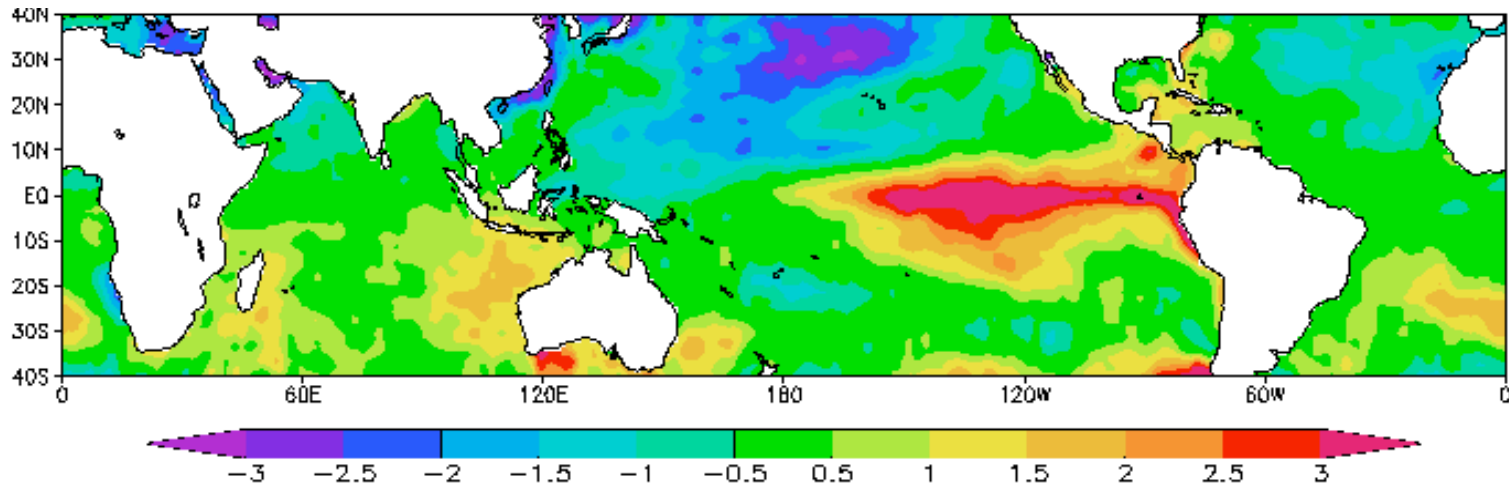
The climatology of GLDAS/Noah soil moisture is higher and closer to the observed climatology than that of GR2/OSU, while the anomalies of all three show generally better agreement (though some exceptions)

Observed (top) and CFS predicted (bottom) SST anomaly for JFM

**FIGURE 5**

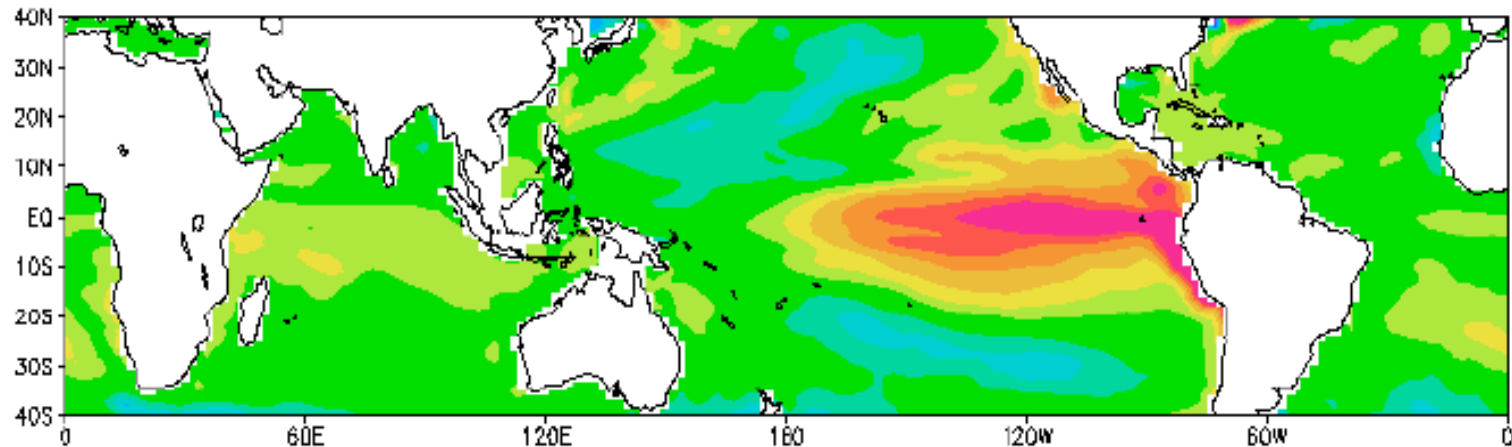
**Observed**

(with respect to 5-year 2000-2004 observed climatology)



**CFS Predicted**

(with respect to CFS 5-year 2000-2004 model climatology)



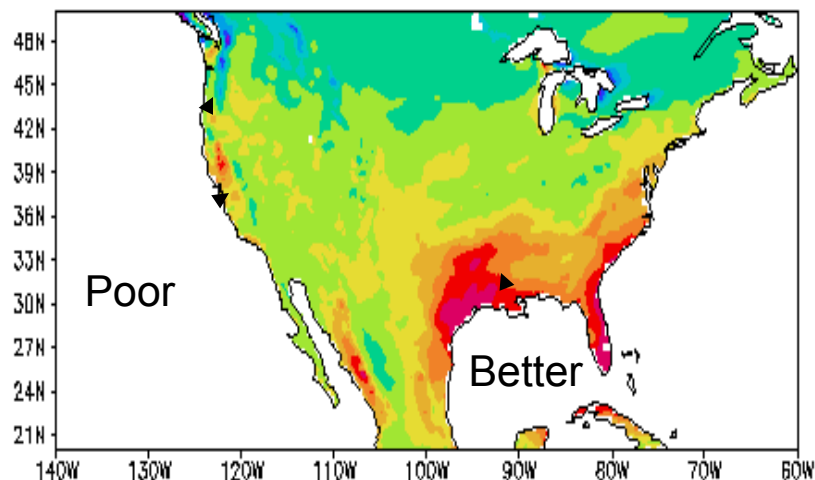
# JFM Precipitation anomaly for Winter 1983 ENSO

## Eta RCM vs CFS vs Observed

(in terms of mean monthly precipitation: mm)

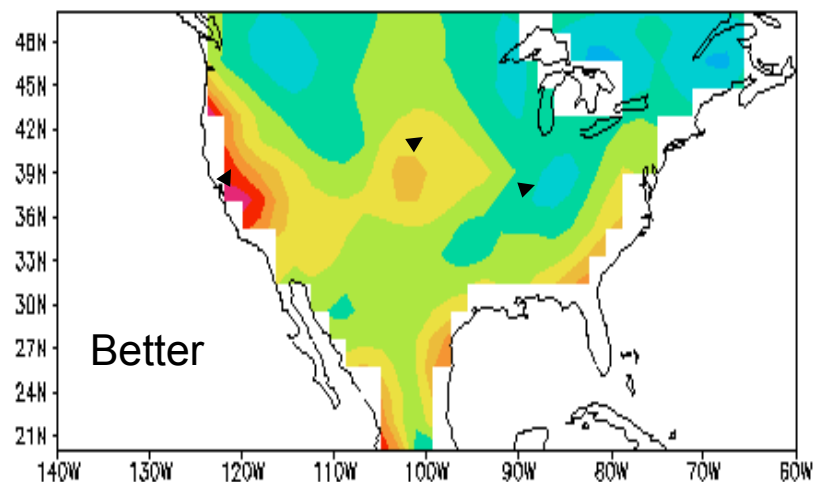
### ETA

1983 EtaRCM - 5 Year Climo



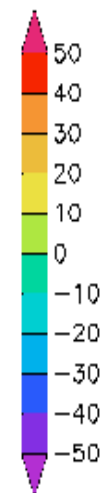
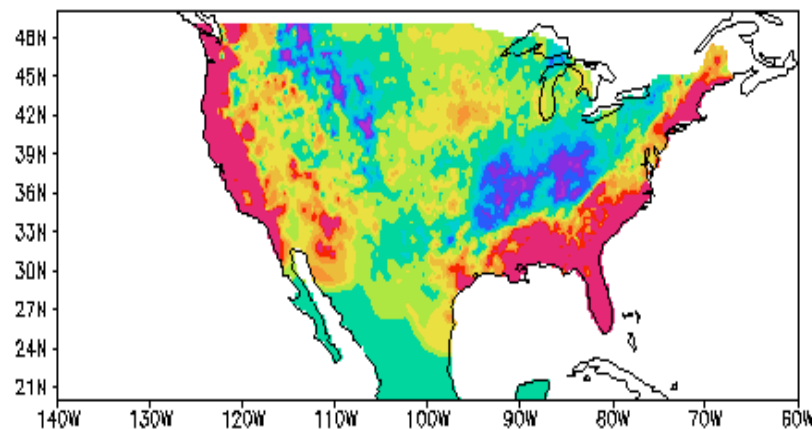
### CFS

83 Avg JFM Precip - 5 Yrs Climo



### Observed

1983 Avgd JFM - 5 Year Climo



**FIGURE 6**

# Observed (top) and CFS predicted (bottom) mean SST anomaly for JJA

## Observed

(with respect to 5-year 2000-2004 observed climatology)

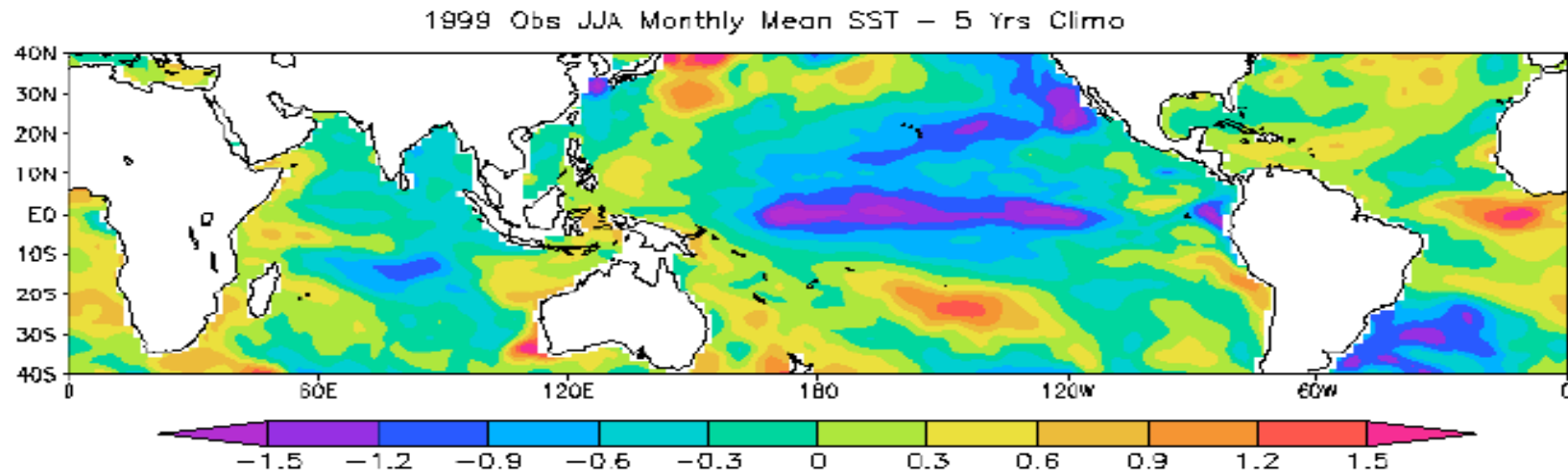
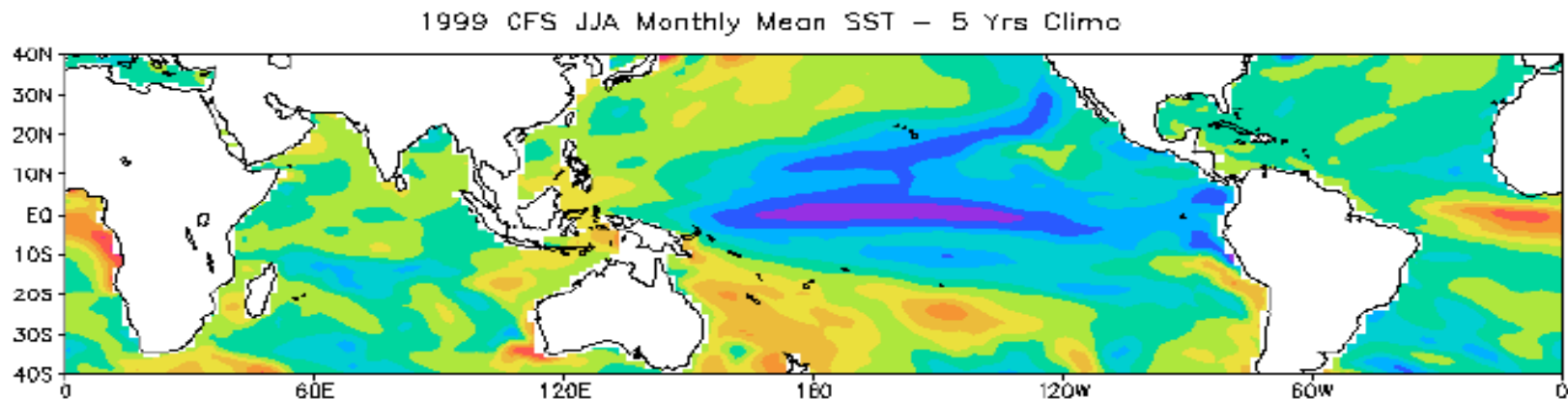


FIGURE 7

## CFS Predicted

(with respect to CFS 5-year 2000-2004 model climatology)





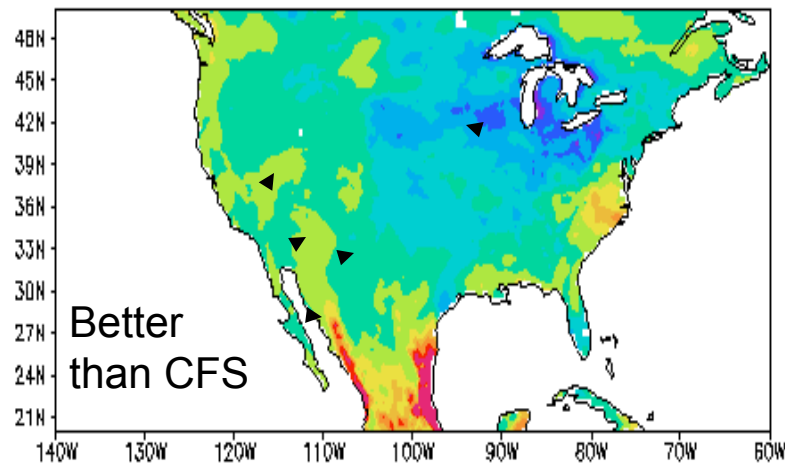
# JJA Precipitation anomaly for Summer 1999

## Eta RCM vs CFS vs Observed

(in terms of JJA precipitation accumulation in mm)

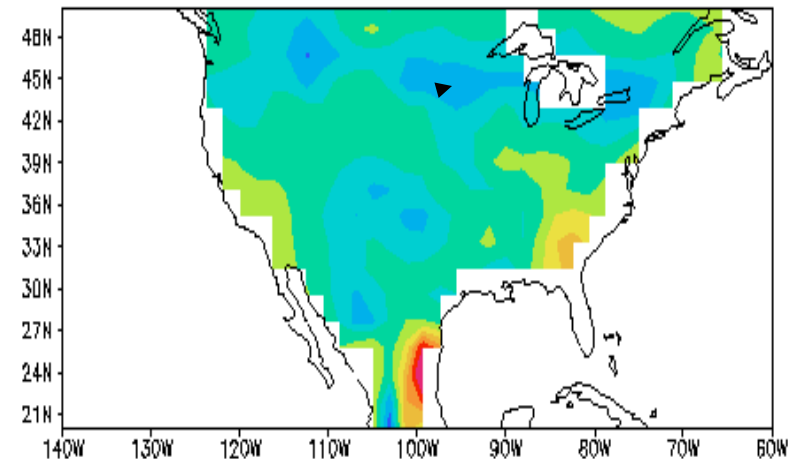
**ETA**

1999 EtaRCM - 5 Year Climo (Prediction)



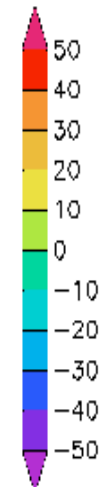
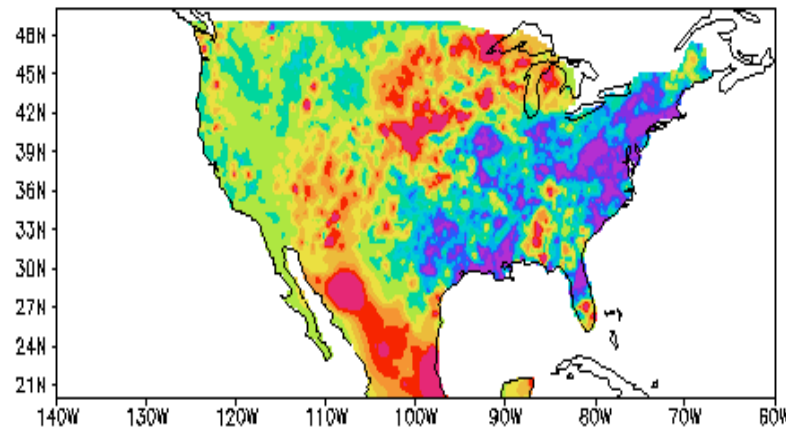
**CFS**

1999 CFS JJA Monthly Precip - 5 Year Climo



**Observed**

1999 Avgd JJA - 5 Year Climo

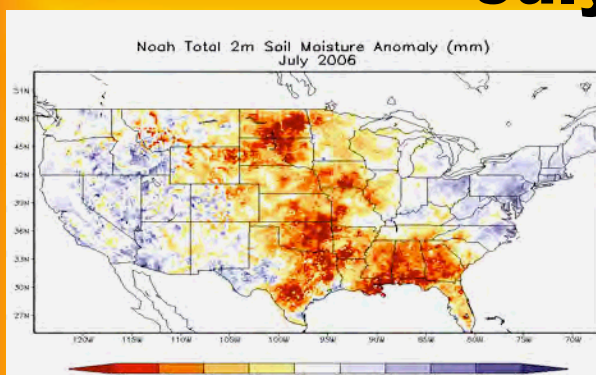


**FIGURE 8**

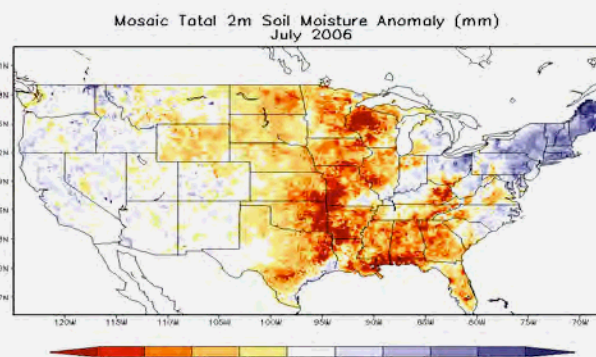


# Monthly Mean Total Column Soil Moisture Anomaly (Model by Model and 4-model Ensemble Mean) with respect to climatology of NCEP 10-year NLDAS run (Oct 96 – Sep 06) **July 2006**

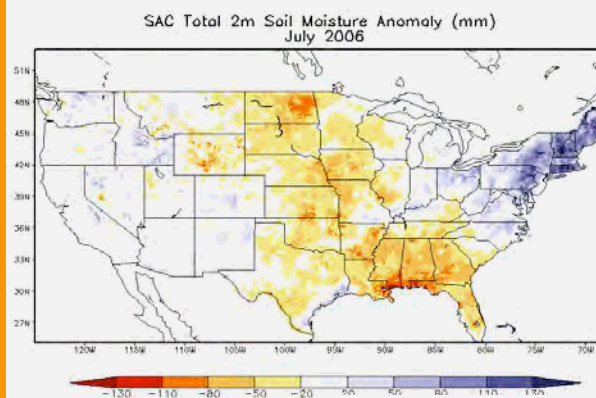
Noah



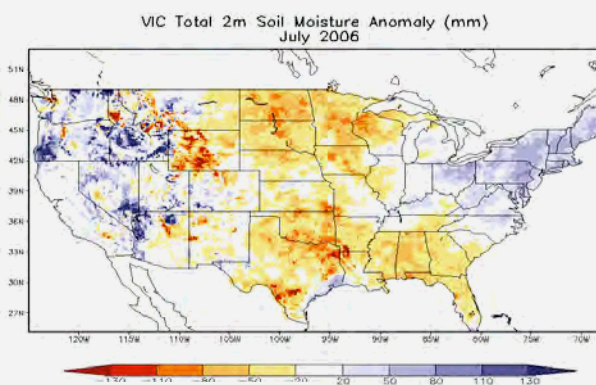
Mosaic



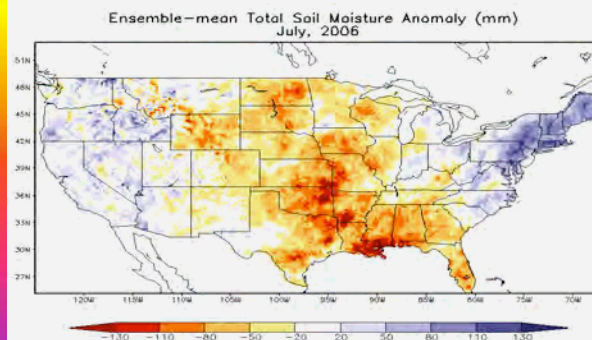
SAC



VIC



**FIGURE 9**

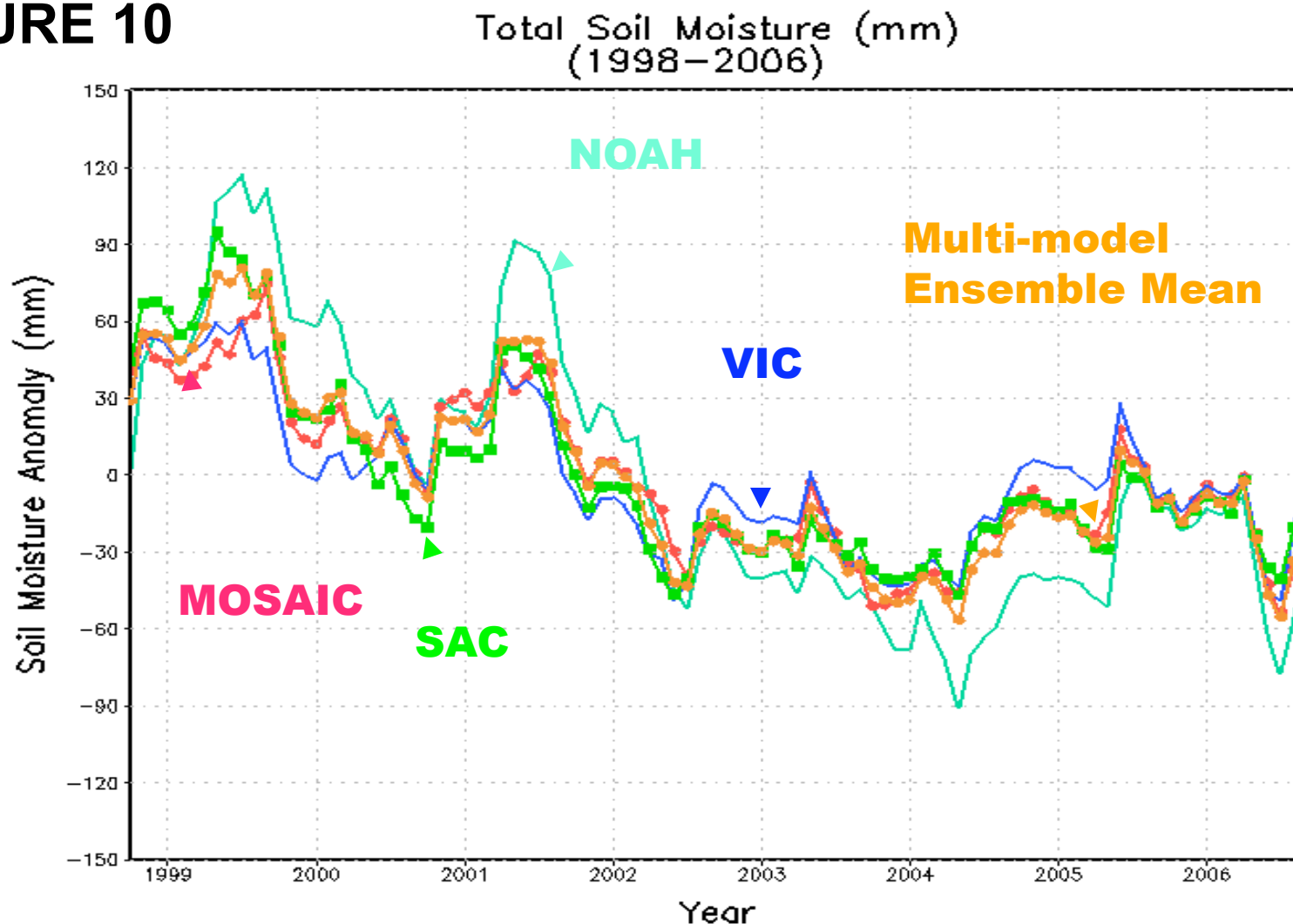


**Multi-Model  
Ensemble Mean  
Anomaly**

b

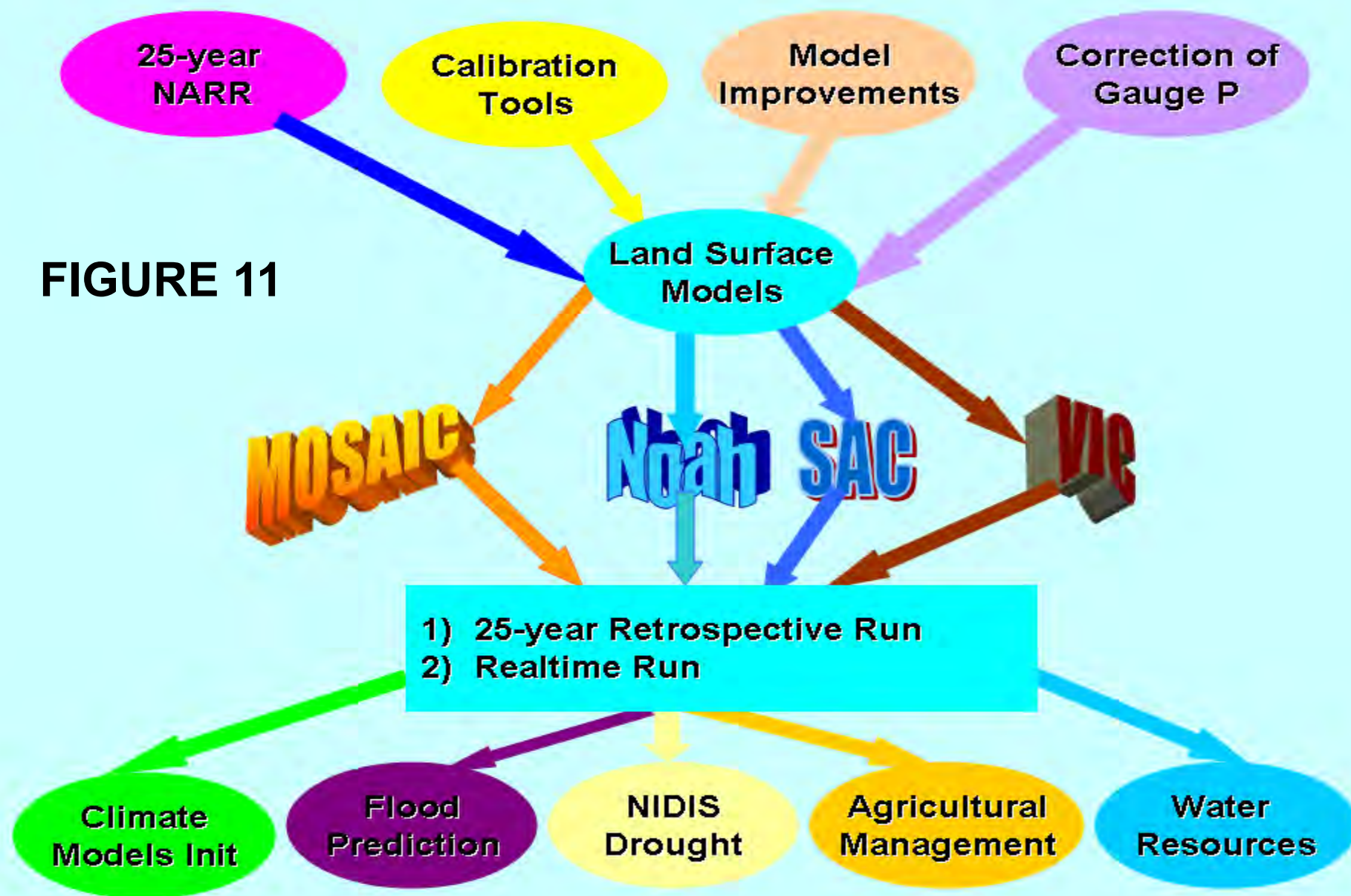
# 10-Year Rerun of NCEP 4-model NLDAS: Monthly Time Series for Northern Great Plains (98W-125W,40N-53N) Model-by-Model Area Average Total Column Soil Moisture Anomaly

**FIGURE 10**



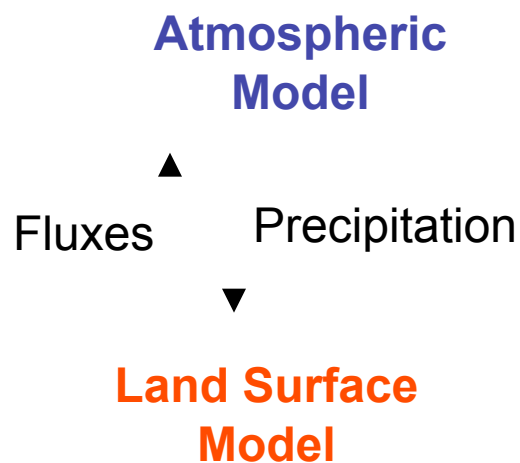
# NLDAS Phase II: Ensemble Monitoring Mode

FIGURE 11



# Ensemble Streamflow Forecasting: Two Possible Approaches

## A) Coupled Models



Runoff  
(ensemble) ▼  
**River Routing Model**

Stream Flow  
(ensemble) ▼

Post Processor

Final Product ▼

## B) Uncoupled Models

precipitation  
▲  
Post Processor:  
bias correction  
of land surface  
forcing, e.g.  
correct QPF bias

Bias-corrected  
Precipitation  
Forecasts  
(ensemble)  
▲  
**Land Surface Models**

Runoff  
(ensemble) ▼

**River Routing Model**

Stream Flow  
(ensemble) ▼

Post processor

Final Product ▼

**FIGURE 12**



# NLDAS Phase II: Ensemble Prediction Mode

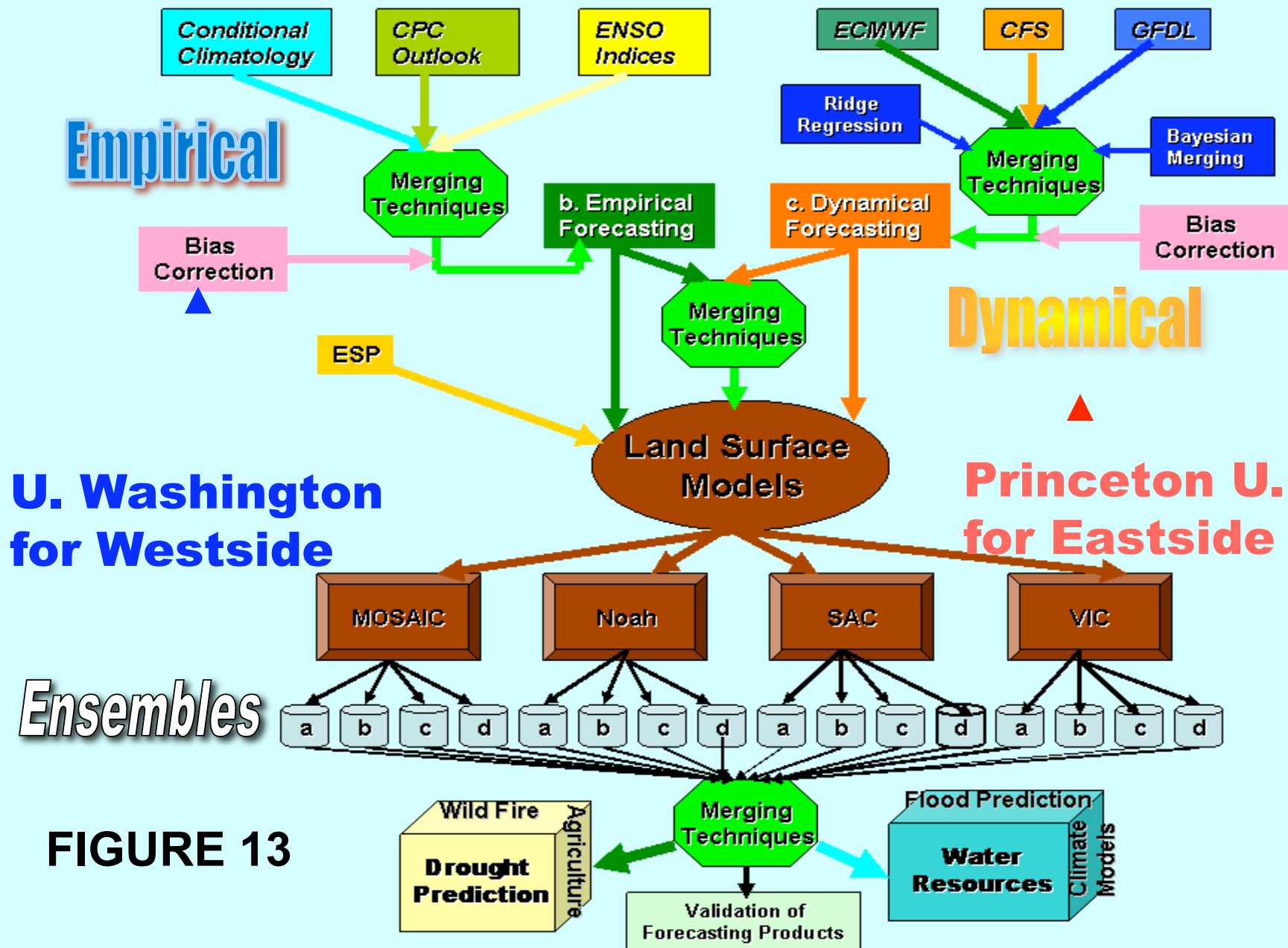
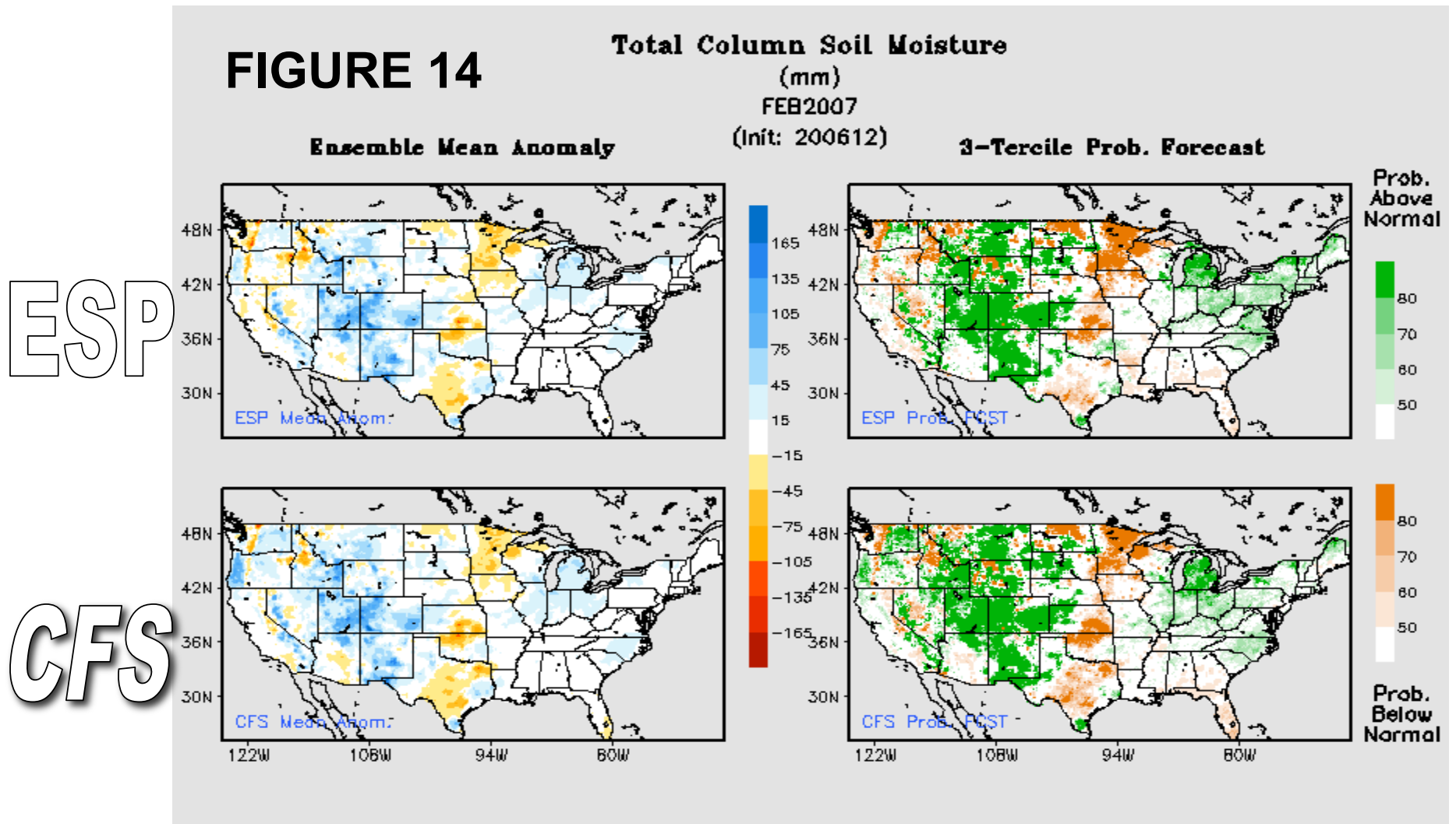


FIGURE 13

# Realtime total soil moisture anomaly prediction for Feb 2007 (from Dec 2006 initial conditions):

via NCEP adaptation of Princeton U. East-Wide System entity that applies NCEP operational CFS ensemble dynamical seasonal forecasts



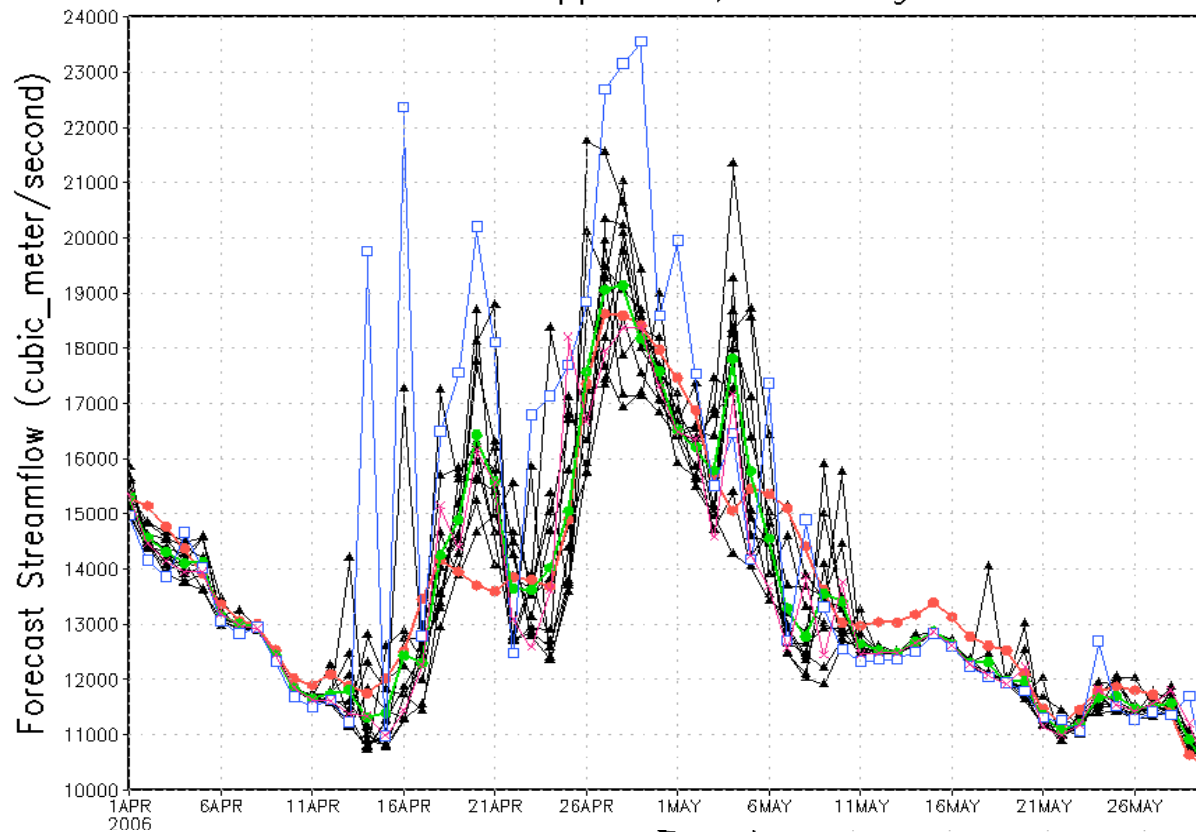
Top Row: Benchmark prediction from traditional empirical method (applying traditional ESP)  
Bottom Row: Experimental dynamical prediction, via VIC model driven by CFS ensemble prediction

Tue Dec 26 21:44:58 EST 2006

FIGURE 15

# Coupled atmosphere-land Ensemble GFS streamflow forecasts

STREAMFLOW ( $\text{m}^3/\text{s}$ ) ens. fcast (360hr)  
for Mississippi River, Vicksburg MS

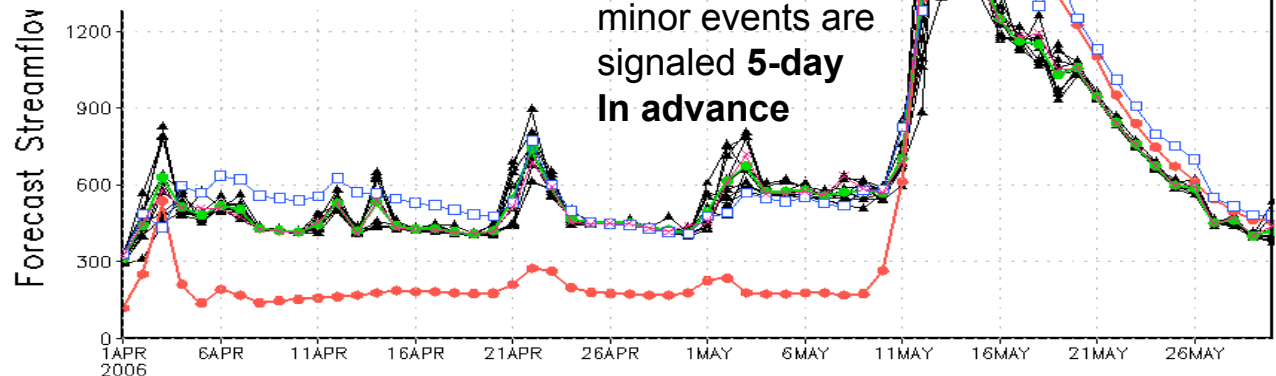


----- GEFS members  
 ----- GEFS ens. mean  
 ----- GEFS control  
 ----- GFS high resolution  
 ----- NLDAS Analysis

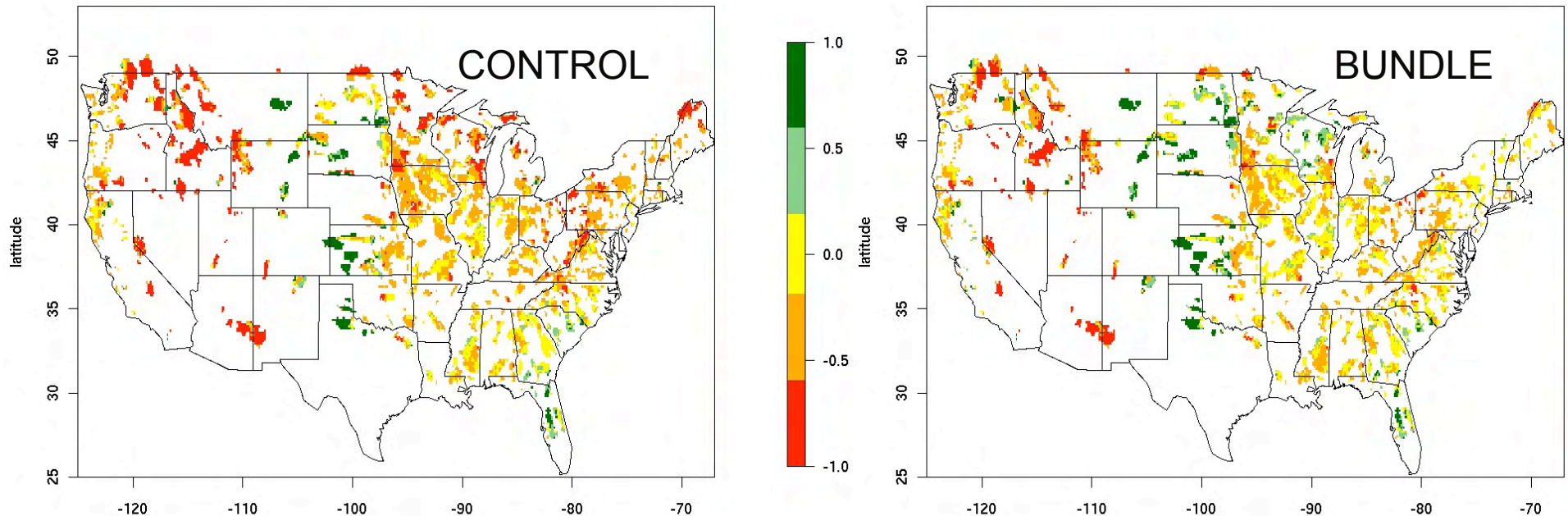
Positive Correlation  
between Forecasts and  
Analysis for all  
Lead times

$\text{m}^3/\text{s}$ ) ens. fcast (120hr)  
-Concord River, Lowell MA

Merrimack-  
 Concord River,  
 Lowell, MA  
 Medium Basin  
 May 2006  
 New England  
 Flood is correctly  
 predicted and some  
 minor events are  
 signaled **5-day**  
 In advance



## Improvements to Noah LSM physics reduce the model's generally negative runoff bias



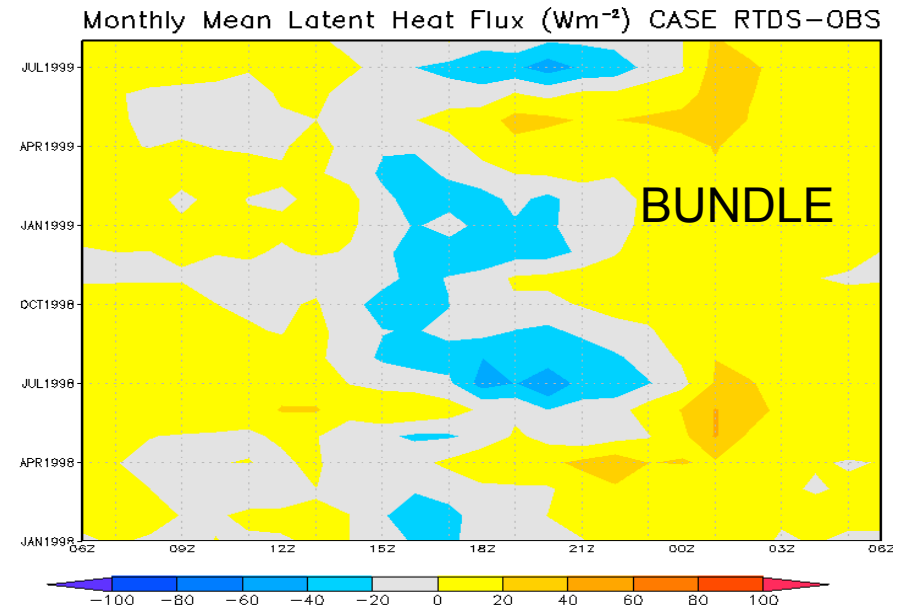
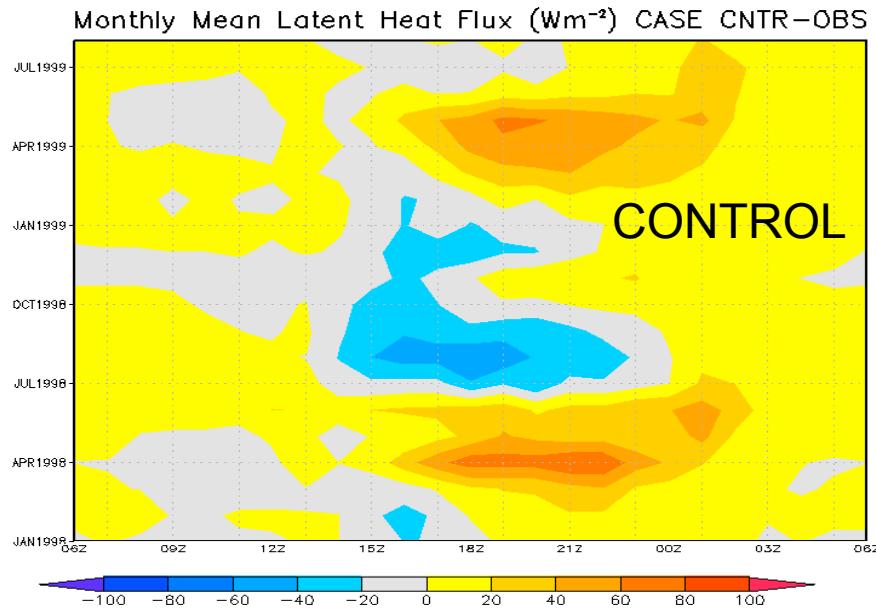
**FIGURE 16**

Normalized bias of mean-annual basin average runoff from 2-year uncoupled Noah LSM simulations (Oct 97 to Sep 99) for selected unregulated basins in the NLDAS test bed for a control version (left panel) and test version (right panel) of the Noah LSM. The test version (labeled “BUNDLE”) includes the seven physical changes listed in Section 5 of the progress report. The changes in the test version reduce the negative runoff bias in the east half of the CONUS. Those basins in central Great Plains with high positive bias (dark green) are likely basins where streamflow is diverted for irrigation and hence should be discarded from the set of validating basins.

Normalized bias is defined as  $[(\text{model} - \text{observed}) / \text{observed}]$

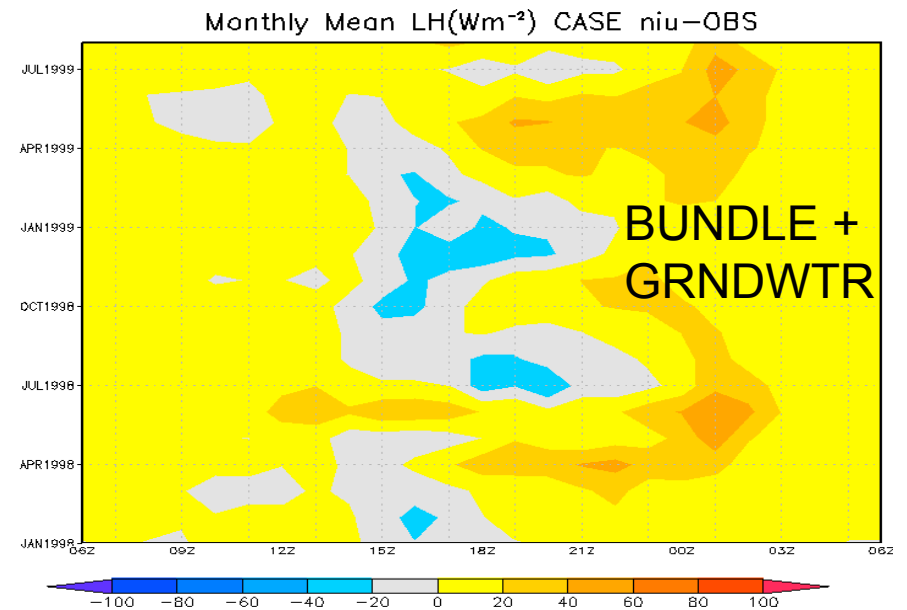


## Diurnal cycle (x-axis) by month of year (y-axis) of differences between Noah simulated and observed surface latent heat flux

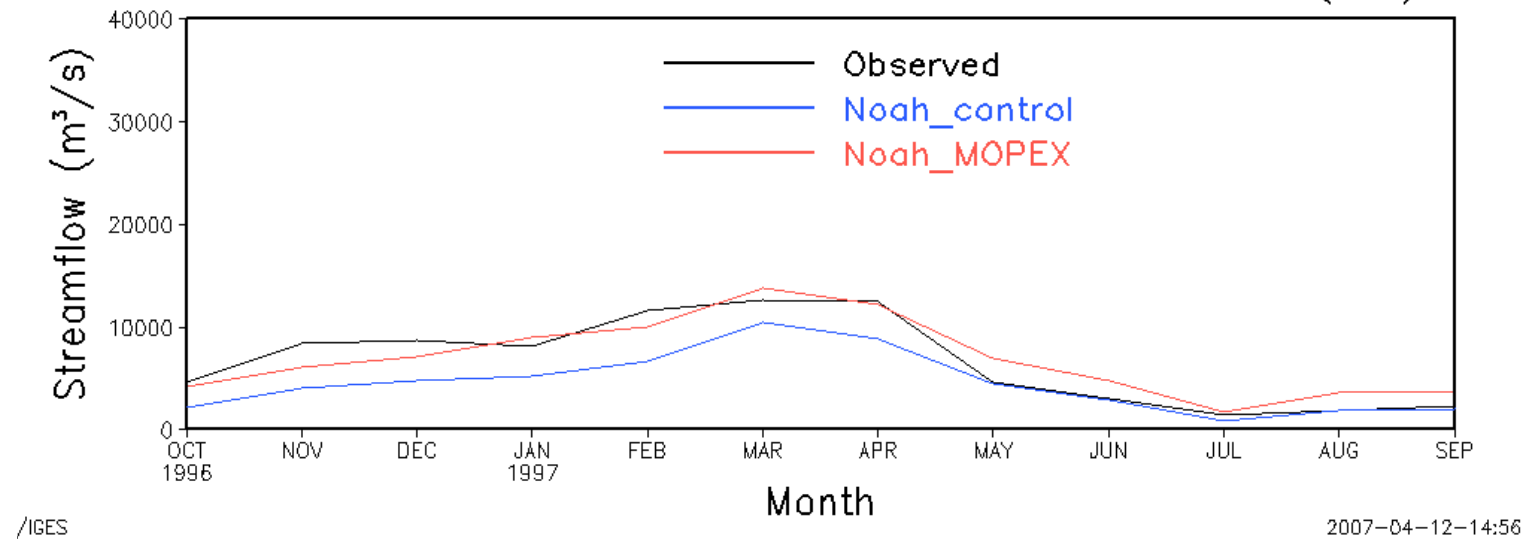


**FIGURE 17**

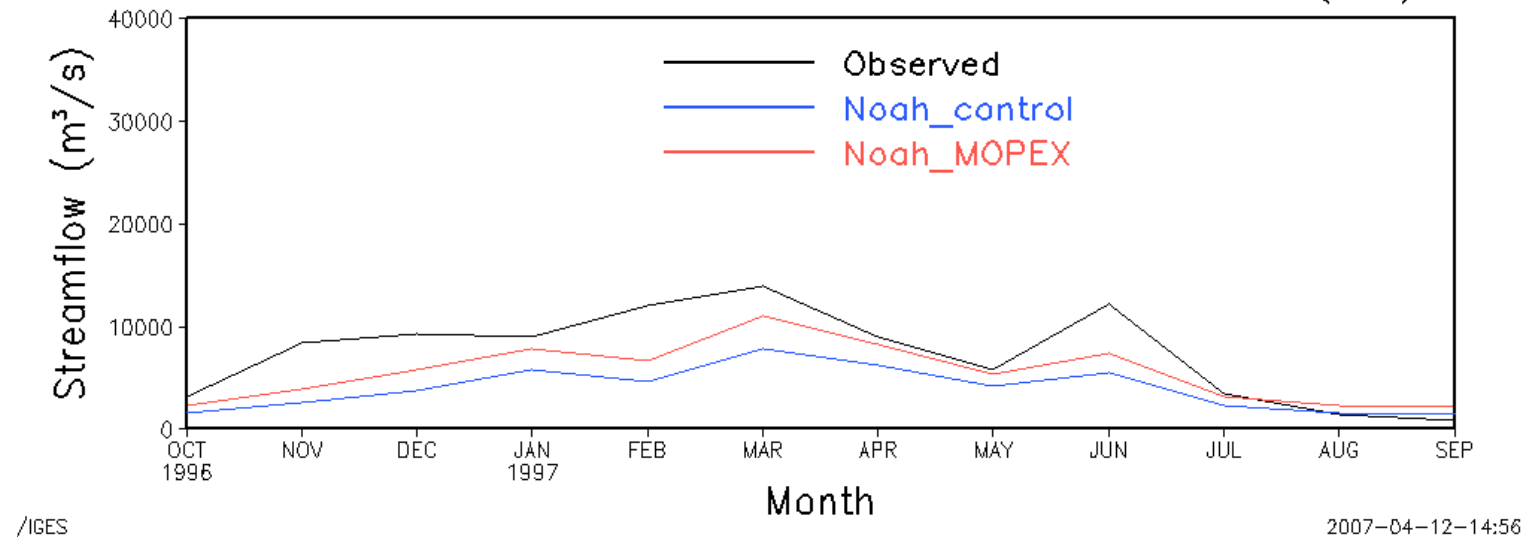
Monthly mean diurnal cycle (horizontal axis) by month (vertical axis) of the difference of model-minus observed surface latent heat flux as computed from the average of such differences at 24 ARM/CART flux stations for a 21-month simulation in the NLDAS test bed of three configurations of the Noah LSM described in the text.



**FIGURE 18** Observed and Simulated Streamflow at Bluo2(OK)

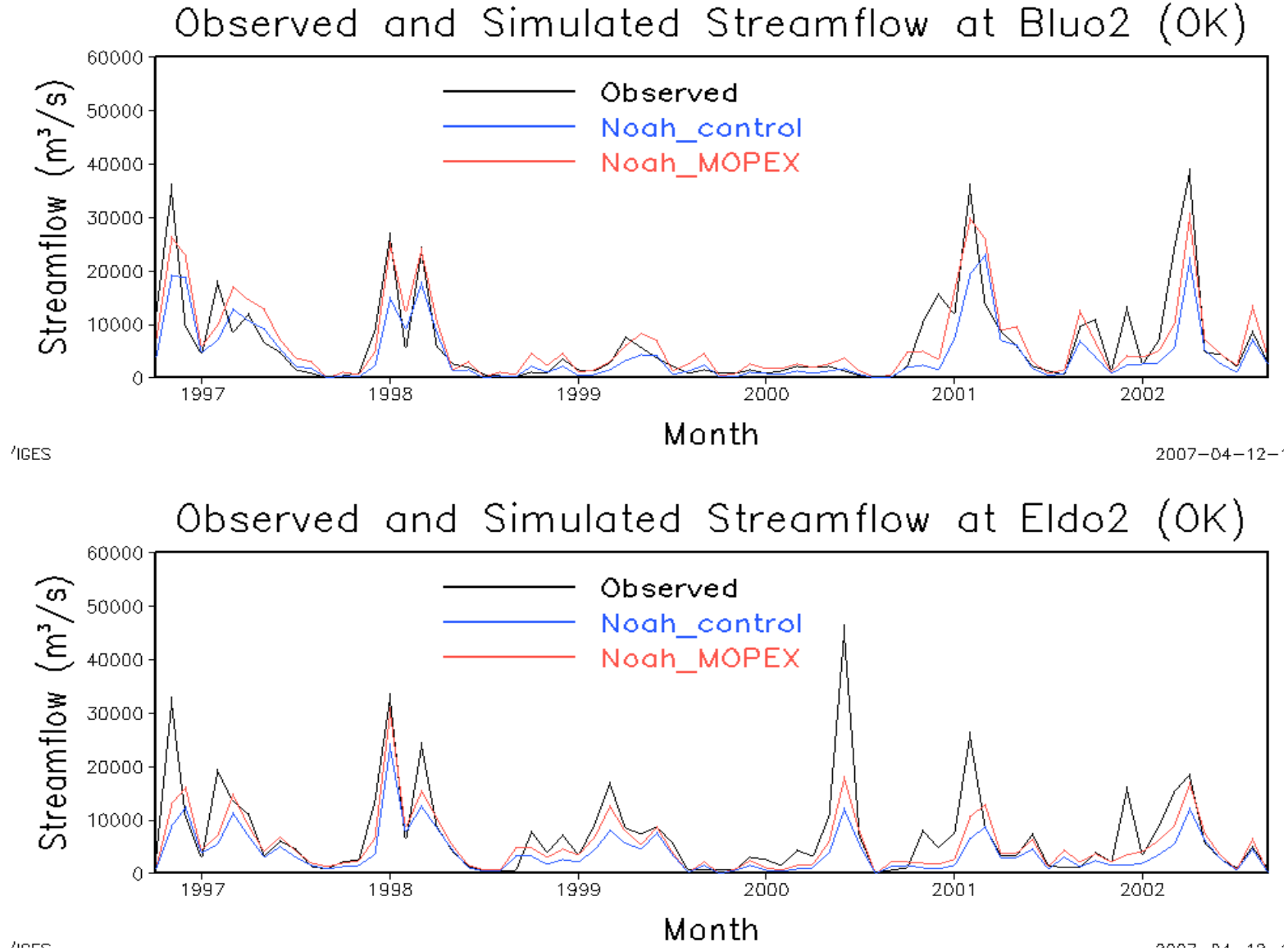


Observed and Simulated Streamflow at Eldo2(OK)

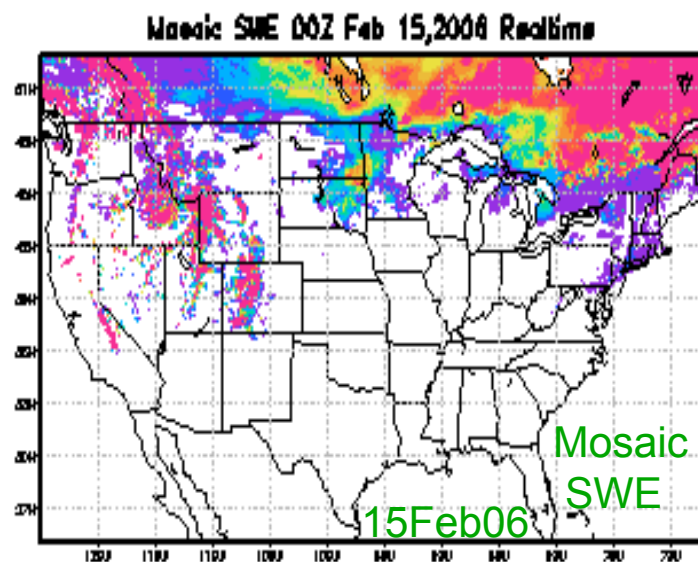
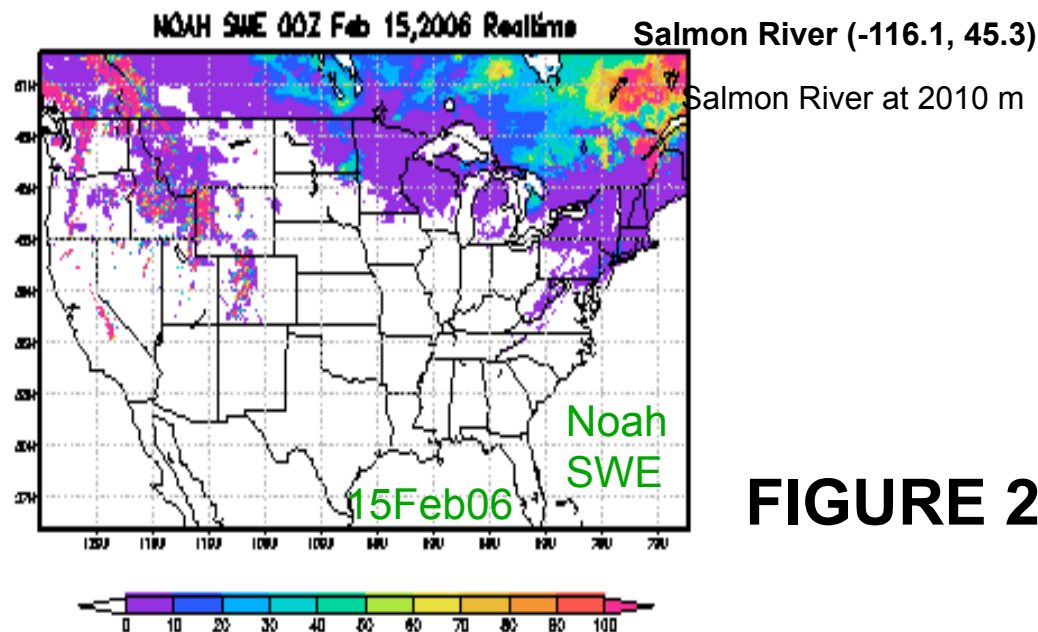


Mean annual cycle from six years (Oct 96 – Sep 02) of observed and Noah LSM simulated monthly streamflow for the Blue River and Eldon River basins in Oklahoma. Changes to two Noah runoff related parameters recommended by the MOPEX project reduces the low bias in the simulation.

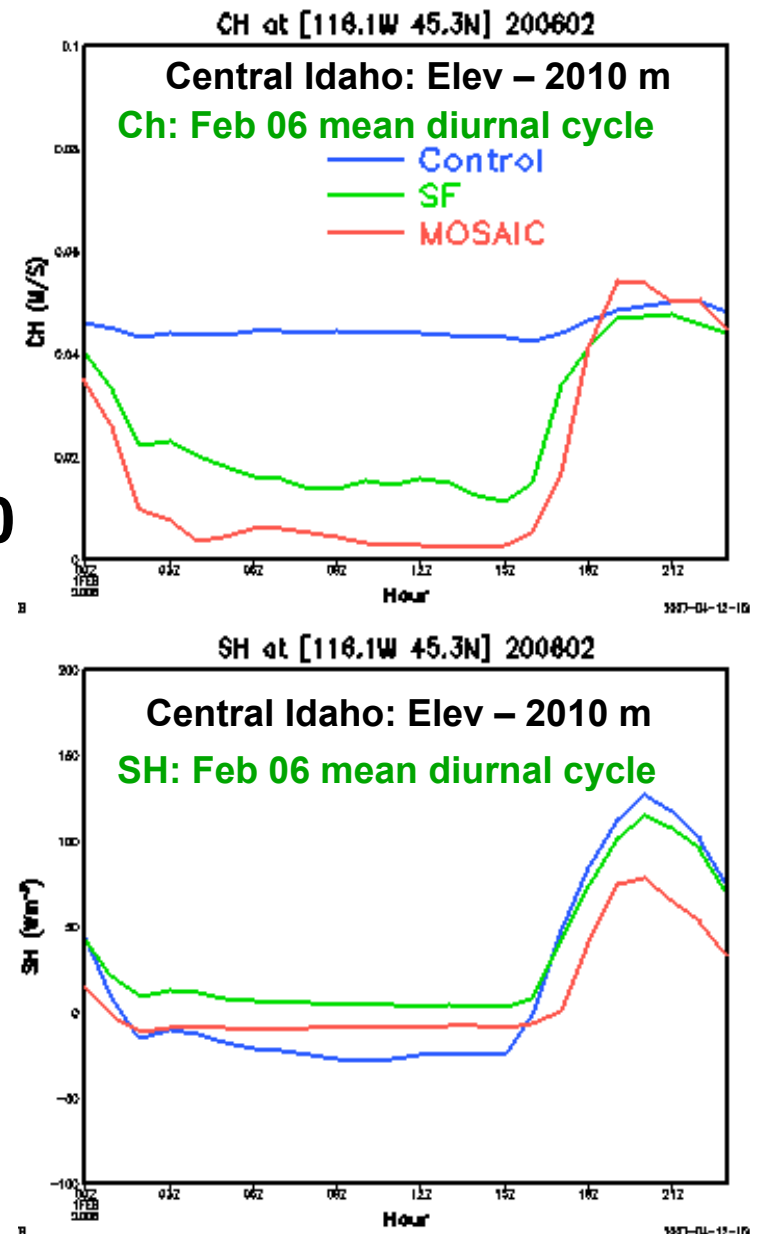
# FIGURE 19



As in Figure 18, but for the monthly time series spanning six years (Oct 96 – Sep 02).



**FIGURE 20**



**Left Column:** Snow water equivalent (SWE, mm) of Noah (top) and Mosaic (bottom) in NLDAS on 15 Feb 06.

**Right Column:** Feb 2006 monthly mean diurnal cycle of (top) aerodynamic conductance (Ch, m/s) and (bottom) surface sensible heat flux (SH) of Mosaic (Red), Noah Control (Blue), and Noah Test (Green) that includes a constraint on stable-regime magnitude of Ch at central Idaho location with elevation of 2010 m.